

Shear Bond Strength and Failure Types of Polymethyl Methacrylate Denture Base Resin and Titanium Treated with Surface Conditioner

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This study compared the shear bond strength and failure types of a polymethyl methacrylate (PMMA) denture base resin to commercially pure (CP) titanium, Ti-6Al-4V alloy, and cobalt-chromium alloy using a metal surface conditioner. The PMMA denture base resin (5 × 5 × 5 mm³) was cured onto disks, 10 mm in diameter and 2.5-mm thick. The shear bond strength of the PMMA resin with the surface conditioner was significantly higher than that without ($P < .05$). There was no significant difference between the types of metal. The conditioned specimens showed mixed failures, whereas the nonconditioned specimens exhibited only adhesive failure at the metal-resin interface. *Int J Prosthodont* 2010;23:246–248.

Titanium is a relatively new material for fabricating removable partial denture frameworks and will most likely become more popular with advances in casting procedures. Failure of the bond at the polymethyl methacrylate (PMMA)–titanium interface can result in prosthetic failure and create space between the metal and PMMA, where oral debris, microorganisms, and stains can reside.

Many studies have evaluated the adhesion of composites to commercially pure (CP) titanium with adhesive primers, and high bond strengths have been reported.¹ However, few studies have evaluated the adhesion of denture base resin to primed titanium for use in removable partial dentures.² CP titanium and Ti-6Al-4V alloy have similar desirable mechanical and physical properties. This study compared the shear bond strength and failure types of a heat-cured resin used as a denture base resin to CP titanium, Ti-6Al-4V alloy, and cobalt-chromium (Co-Cr) alloy.

Materials and Methods

Twenty disks (10 mm in diameter, 2.5-mm thick) were made for each of the three groups (CP titanium, Ti-6Al-4V alloy, and Co-Cr alloy). The disk surfaces were finished with no. 600 silicon carbide paper (CC-600Cw, Daesung) under water followed by 250-μm grain-sized aluminum oxide for 5 seconds using a grit blaster (Microsand blaster, Phoenix Electric). The emission pressure was 4.5 kgf/cm² with the nozzle positioned approximately 5 mm from the surface. The grit-blasted cast disks were washed in acetone for 10 minutes using an ultrasonic cleaner (Ultraschall, Krupp). A wax cube (5 × 5 × 5 mm³) was attached to the disks to fabricate a part of the resin tap (Fig 1a). The wax cubes were fixed in the same dimensions by preparing silicone casts and pouring the melted wax. Sixty wax cubes were fabricated using the same parameters. The wax was adhered to the dried specimens. The specimens were then invested in a conventional manner. After hardening the investment, the remaining wax was removed using hot water. Immediately after drying the cleaned disks, a metal conditioner (Alloy primer, Kuraray Medical) was applied to the air-abraded surfaces using a sponge pellet according to the manufacturer's instructions. Specimens with unprimed disk surfaces were prepared as controls. The resin separator was brushed on the investment, and the heat-cured denture base resin (Vertex-RS, Dentimex) was then applied and polymerized according to the manufacturer's instructions (Table 1, Fig 1b).

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Table 1 Materials Used in This Study

Identification	Composition	Manufacturer
CP titanium	Ti > 99.0%	Kobe Steel
Ti-6Al-4V	Ti > 89.0%, 6.0% Al, 4.0% V	Kobe Steel
Biosil F	Co 67%, Cr 28.5%, Mo 5.3%	DeguDent
Alloy primer	MDP, VBATDT	Kuraray Medical
Vertex-RS	PMMA/MMA	Dentimex

CP = commercially pure; MDP = 10-methacryloyloxydecyl dehydrogen phosphate; VBATDT = 6-(4-vinylbenzyl-n-propyl)amino-1,3,5-triazine-2,4 dithione; PMMA = polymethyl methacrylate.

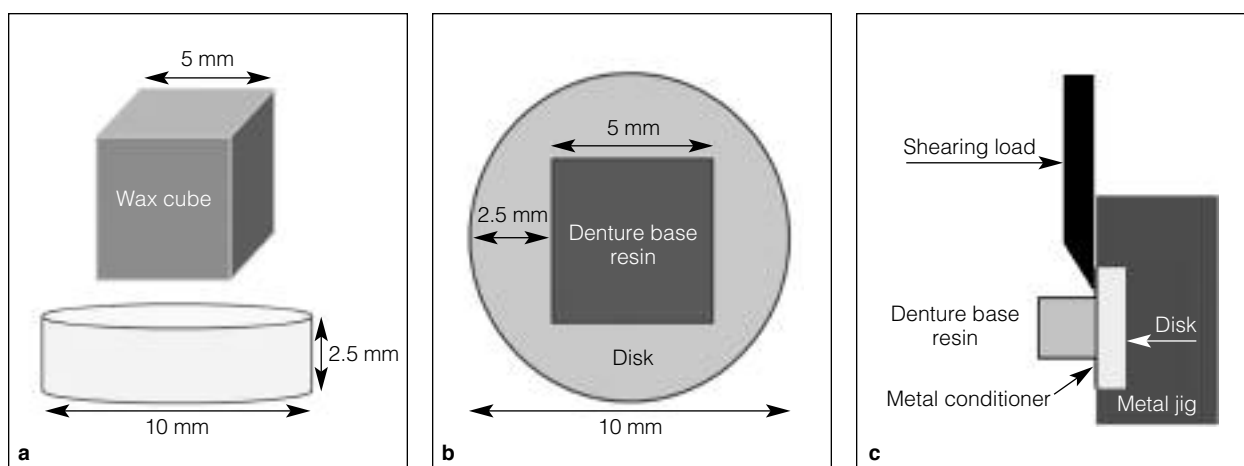


Fig 1 Schematic diagrams of (a) the wax cube and disk, (b) the denture base resin on the disk, and (c) the shear bond strength test.

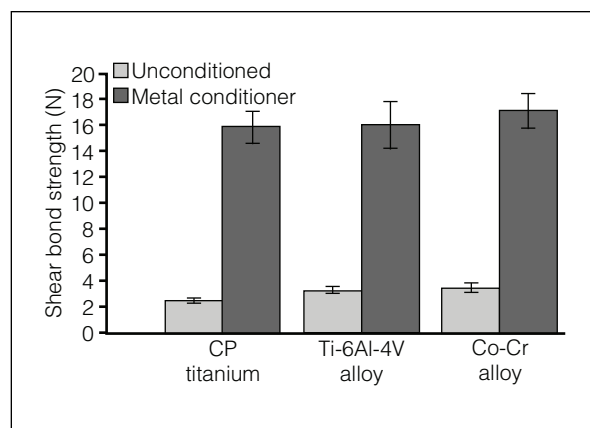
The shear bond strengths were measured using a screw-driven universal testing machine (STM-5, United Calibration) at a crosshead speed of 1.0 mm/min (Fig 1c). The fractured surfaces of the specimens were examined via optical microscopy (BX51 TRF, Olympus) at a magnification of $\times 50$ to assess the type of bond failure. The failures were classified as adhesive failure if they occurred at the metal-PMMA interface or mixed failure, which included both adhesive and cohesive failure.

The means and standard deviations of the shear bond strength ($n = 10$) were calculated and analyzed statistically using two-way analysis of variance and the Tukey test. Statistical analysis was performed using SPSS version 12.00 (SPSS).

Results

The shear bond strength of the heat-cured denture base resin was significantly higher in the group treated with the metal conditioner ($P < .05$) (Fig 2). However, there were no significant differences between the types of metal.

Without the metal conditioner, only adhesive failure was observed in all specimens. With the metal conditioner, the CP titanium and Ti-6Al-4V alloy specimens showed mixed failure; only one adhesive failure was observed in the Co-Cr alloy group (Table 2).

Fig 2 Mean (\pm standard deviation) shear bond strength of the experimental groups.**Table 2** Distribution (%) of the Failure Types in Each Study Group (n = 10)

Failure type	Unconditioned			Metal conditioner		
	CP Titanium	Ti-6Al-4V alloy	Co-Cr alloy	CP Titanium	Ti-6Al-4V alloy	Co-Cr alloy
Adhesive	100	100	100	–	–	10
Mixed	–	–	–	100	100	90

CP = commercially pure.

Discussion

Jemt et al reported that implant-supported prostheses with machined titanium had bonding problems between the machined surface and PMMA.³ Kojima et al synthesized a 6-(4-vinylbenzyl-n-propyl)amino-1,3,5-triazine-2,4-dithione (VBATDT) monomer, which did not contain a free mercapto group, and reported that the VBATDT primer improved the bond durability of an MMA-PMMA-TBBO (tri-n-butylborane partially oxide) resin bonded to precious metal alloys.⁴ In this study, the VBATDT-containing metal conditioner had a significantly positive effect on the bond between the heat-cured denture base resin and the metal alloys (Fig 2).

The findings regarding the failure type (Table 2) are similar to those reported by Ohkubo et al, who observed bonding failure occurring between the resin and metal interfaces.⁵ Mixed failure was observed in the resin and metal interfaces of the groups treated with the metal conditioner, which can be attributed to the chemical bonding between the metal and resin.

Conclusion

Within the limitations of this in vitro study, it was found that the conditioner containing VBATDT had a significantly positive effect on the bond between the PMMA denture base resin and the metal alloys ($P < .05$).

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